Hands Mill Dam Removal Preliminary Engineering Report





PROJECT NO. P

PREPARED FOR:

 20-007
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1. PROJECT PLANNING

1.a. Location

The Town of Washington in Orange County is a rural residential community near the geographical center of Vermont. It is bordered by the Towns of Barre, Orange, Williamstown, Chelsea, Corinth, and Vershire. Washington is hilly and picturesque and contains 26,216 acres of land. It is located in the physiographic region known as the Vermont Piedmont: a plateau that has been dissected by streams and subdued by glaciations. Generally, slopes are moderately steep. From a minimum elevation of just under 1,000 feet along the First Branch of the White River, the terrain climbs to over 2,000 feet in many places. Michigan Hill, at 2,402 feet, is the highest point. The Town's stony, often steep, and occasionally wet glaciated soils present some widespread and significant limitations for development and the floodplain valley of the Jail Branch has historically been the site of most human activity in Washington.

According to the 2010 U.S. Census, Washington has a total population of roughly 1,039 people living in 419 households. Until the second half of this century, agriculture, mill-powered manufacturing, mining and forestry were the Town's employment mainstays and most residents made their living in town. Now only approximately 15% of Washington's employed residents work in town, there are only a few retail establishments and no large employers, hence Washington has evolved into a bedroom community.

The proposed limits of disturbance for the project area include Town Parcel #7105.00 as well as portions of eight surrounding privately owned parcels. The proposed limits of disturbance encompass 11.42 acres; however, the extent of ground disturbance totals 1.45 acres. Table 1 includes a list of properties within the project area including parcel identification numbers and street addresses. The list includes residential properties as well as the Town parcel where the Hands Mill Dam is located. The extent of the proposed limits of disturbance and parcel boundaries are shown in Sheet 2 of the 30% Design plans provided in Appendix A.

Street Address	Parcel Number/SPAN	Owner Name	Use	Approximate Parcel Size (acre)
16 Woodchuck Hollow Road	693-220-10094	Roger Buswell	Residential	0.25
39 Woodchuck Hollow Road	693-220-10573	Russel & Lois Deberville	Residential	1.25
110 Woodchuck Hollow Road	693-220-10319	Lucy Bourgeault	Residential	1.0
228 Woodchuck Hollow Road	693-220-20355	Dominique Lafond & Keith Copeland	Residential	1.0

Table 1. Properties Within Project Area

53 Vermette Lane	693-220-10168	Mary A & James P Driscoll	Residential	2.7
13 Vermette Lane	693-220-10629	Auston Norton, Life Estate	Residential	1
111 Vermette Lane	693-220-10612	Norman C & Claire C Trepanier	Residential	1
273 West Corinth Road	693-220-10477	Jon Pallas	Residential	1.2
2895 VT Route 110	693-220-10678	Town of Washington	Town Property	3.5

1.b. Environmental Resources Present

Most of the project area is forested or undeveloped land. Jail Branch flows from east to west through the project area, then turns back to the northwest downstream of the Hands Mill Dam. A small, unnamed tributary flows into Jail Branch at approximate station 14+50 along river right. Wetland areas are present in the project area, along the left and right bank of Jail Branch. Project stations and wetland boundaries are shown on Sheet 3 of the 30% Design Plans provided in Appendix A. Additional information about environmental resources present is provided in this project's Environmental Information Document (EID).

1.c. Population Trends

The Town of Washington's population grew from 937 in 1990 to 1,061 in 2000 and then declined by 2% from 1,061 to 1,039 in 2000-2010 (US Census and 2013 Washington Town Plan). The 2013 Town Plan projected a population increase to 1,311 residents in 2020.

As noted in Section 2.1 of the Town Plan, Washington is one of the least populous towns in the Central Vermont Region, but has seen some of the most rapid population growth over the past few decades. However, the population is still below its historical high of 1,4000 residents. Planning initiatives undertaken by the Town are intended to balance accommodating expected future growth and the rural character of the Town.

1.d. Community Engagement

The alternatives and selected design described in the PER were presented to and discussed with stakeholders at several stages in the design process. The Winooski Natural Resources Conservation District (Winooski NRCD, referred to in this report as the District) hosted two site visits and several stakeholder meetings (July 24, 2020; August 25, 2020; September 28, 2020; October 28, 2020; December 9, 2020), to coordinate work and solicit partner and public input on the preliminary 30% Design Plans and historic and archeological resources studies. Partners who participated in these meetings included: 1) The Vermont Department of Environmental Conservation (DEC) - Dam Safety Division; 2) DEC - Floodplains Manager; 3) DEC - River Management Program; 4) DEC - Wetlands Program; 5) Vermont State Historical Preservation Office; 6) Vermont Emergency Management; 7) Vermont Fish and Wildlife Department; 8) United States Army Corps of Engineers; 9) United States Fish and Wildlife Service; 10) Central Vermont Regional Planning Commission; 11) The Town of Washington staff and Select Board; 12) The Nature Conservancy; 13) Vermont Natural Resources Council; and 14) Central Vermont and Mad Dog Chapters of Trout Unlimited. The long list of partners reflects great enthusiasm for the project and its potential to address multiple benefits from hazard mitigation to trout habitat connectivity and stream equilibrium. Regulatory agencies have

actively shared comments throughout preliminary design such that we are confident in our proposed scope of work and budget estimates. Central Vermont Trout Unlimited has offered additional support by taking on fundraising responsibilities and providing legal research in-kind. Vermont Natural Resources Council provided in-kind wetlands delineation services for the preliminary design phase and The Nature Conservancy provides on-going technical assistance and has earmarked a cash-match towards project grants.

All adjacent landowners were contacted in person at the launch of the preliminary design phase. The District gathered landowner contact information and invited landowners to a public presentation at the Town Select Board meeting on January 14, 2020. The District has provided the Town Select Board regular project updates and launched a project site page (winooskinrcd.org/handsmilldam) to provide public access to project documents. Town Select Board and staff also have participated throughout all stakeholder meetings.

Future outreach and community engagement will include the completion of a visual rendering of the dam removal in February 2021 and the District's continuing work in coordination with the town clerk to plan a press release on project progress and public forum to address questions and concerns. Final design work to be completed in 2021 will also include solicitation of public comment.

2. EXISTING FACILITIES

2.a. Location Map

A map of the Hands Mill Dam and surrounding properties, as surveyed during the topographic survey is provided in Sheet 3 of Appendix A. A photograph of the existing dam structure is provided in Figure 1. The existing conditions at the project site are described below.

2.b. History

Hands Mill Dam is located in and owned by the Town of Washington, in Orange County, VT. The dam was constructed in 1860. The dam is made of masonry and stone ranging in size from medium gravel to small boulders in some sections, and primarily of concrete in other sections. Additionally, the dam has a history of past event failures and damages. According to the 2020 Draft Historic Resource Review and Archeological Resources Assessment Report by the University of Vermont Consulting Archeology Program, the waterpower at the Hands Mill Dam site was initially developed by 23-year-old Charles W. Huntington who built the first dam and saw mill at this location in 1865. On April 8-9, 1895, a rainstorm caused a freshet that "badly wrecked" the ... saw mill (Vermont Watchman and State Journal April 17, 1895; Waterbury Record April 23, 1895). In this event, "the pressure of water in the racecourse [sic] from the swollen pond was so great that the embankment was washed out to some extent. Land was inundated and a portion of the highway submerged" (page 11). The dam failed again November of 1927 at which point the earthen embankment was replaced with cement (page 13). By 1950 the mechanical feature of the dam had been abandoned and the dam was used primarily to store logs for the co-located saw mill (page 14). The town acquired the dam in 1958. A Historic Resource Review and Archeological Resources Assessment Report developed by the University of Vermont Consulting Archeology Program in December 2020 provides more thorough historic information on the dam and is provided under separate cover.

2.c. Condition of Existing Facilities

The Hands Mill Dam is a partially breached stone masonry and concrete structure located along the Jail Branch in Washington, Vermont. The visual portions of the dam measure approximately 165 ft long and 12-16 feet high. The principal spillway is approximately 30 feet long and consists of eroding concrete and stone rubble. A concrete and stone rubble wall extends for approximately 65 feet to the right of the spillway and visible portions of a concrete training wall extend for approximately 70 feet to the right of the rubble wall. The dam impounds a pond with a surface area of 2 acres at normal pool elevation.

The DEC Dam Safety Division has been conducting periodic dam safety inspections for a number of years and inspections reports indicate the dam has been in a continually deteriorating condition. The dam is currently classified as a Significant Hazard potential dam and recent Dam Safety reports indicate that a sudden failure could cause "probable loss of life and property damage." (see Hands Mill Inspection Reports and Dam Breach Report provided under separate cover). This potential loss of life may trigger a reclassification to "High Hazard" under Vermont's new Dam Safety regulations; new DEC rules are in draft form with adoption of those rules scheduled for July 2022. Compounding the hazard classification risks is the dam's current condition. The dam is partially breached, and the breach progresses during large storm events. The concrete and stone rubble wall to the right of the spillway has been significantly scoured and is cracking in the exposed section of the spillway and dam. The wall consists of concrete and large stones; the concrete is deteriorating in several areas and there has been significant loss of dry-laid stones. Several large stones and pieces of concrete have fallen off the wall which appears to be impacted by overtopping events. The dam crest is in poor condition with overtopping in multiple locations and a partial breach near the mid-section. The principal concrete spillway is cracked and scoured, partially breached and water is flowing through (within) the dam. The low-level sluiceway is about 12' long through the dam and appears inoperable. Since at least 1984, Dam Safety inspection reports consistently emphasize that the dam is in poor condition and continues to deteriorate. Reports recommend the owner take actions to either reconstruct or remove the dam and restore the upstream channel.

2.d. Financial Status of any Existing Facilities

The Hands Mill Dam is currently owned by the Town. Current operations and maintenance (O&M) work is limited to clearing of any debris collected at or just upstream of the dam and is performed by the Town. This work is typically required during the spring and/or summer. Anticipated annual O&M costs following construction of the project will be limited to floodplain vegetation monitoring, re-seeding or re-planting as needed, and monitoring of upstream banks for sloughing. Post construction annual maintenance and monitoring will be paid for by the Town.

2.e. Water/Energy/Waste Audits

Not needed or applicable.



3. NEED FOR PROJECT

As described above, the Hands Mill Dam is in poor condition. Removal of the dam is a mitigation activity that will eliminate the risk of dam failure and reduce or eliminate the damage to property or loss of life. This section describes the need for the project in terms of health, sanitation, security and aging infrastructure. The third category for describing project needs, reasonable growth, is not applicable to this project.

Failure of the Hands Mill Dam could potentially impact several road crossings, several homes and businesses, and a school downstream. The DEC Dam Safety Division ran a DSS-Wise Lite model of the Hands Mill Dam and downstream areas to assess potential impacts. While several downstream properties and roads may be inundated with relatively shallow flood waters in the event of dam failure, posing a health and safety risk, the main risk driver at the project site is the residential property immediately downstream of the dam at 16 Woodchuck Hollow Road. In addition to a house, a mobile home has also been observed at this property. Based on the DEC analysis, the water depth and velocity at the house would approach or slightly exceed survivable limits, and the water depth and velocity at the mobile home would exceed survivable limits, in the event of a dam failure.

A septic tank and leach field mound system exists along river left and immediately adjacent to the dam at 16 Woodchuck Hollow as well. In the event of dam failure, the potential for impacts to this system is high and could result in the release of septic waste on to the property, into floodwaters, or some combination thereof.

As indicated in the dam inspection reports and as discussed in Section 2, the Hands Mill Dam is in a deteriorating condition. The poor condition and age of the dam make continued maintenance and repair of the dam infeasible.

4. ALTERNATIVES CONSIDERED

An alternatives analysis was completed in 2020 as part of this project. Stone assessed a total of four options for dam removal, including a "no action" alternative of leaving the dam in place. A phased dam removal was also discussed with stakeholders; however, due to the poor condition of the dam, and anticipating that the first phase of removal could result in a complete collapse of the dam, phased removal was not further examined as part of this project.

Stone presented the alternatives to the District and stakeholders at the stakeholder check-in meeting on September 28, 2020. The details and costs for each alternative were presented and discussed amongst the group. While partial dam removal associated with two of the four alternatives was more economical, ultimately the depths of excavation required at the dam to construct the pilot channel and restore long-term channel equilibrium made those alternatives infeasible. Refinements of conceptual designs prior to the September 28, 2020 meeting concluded that the concrete training wall located river right of the spillway would have been undermined by excavation and unstable over time. Therefore, together with stakeholders and District, the alternatives analysis effort concluded that full dam removal was the only feasible removal alternative. Following the meeting, the selected alternative was run in the project hydraulic model. Life cycle costs were also developed for the selected alternative.

4.a. Description

4.a.i. Alternative A1: No Action

Alternative A1 was the no action alternative. Under this alternative the dam and impounded sediment would remain in place. Given the trajectory of historical inspections and current state of the dam, the potential for dam failure would be expected to increase over time.

4.a.ii. Alternative A2 – Removal of 44 linear feet

Alternative A2 included removal of 44 linear feet of the dam, encompassing the embankment section and principal spillway only. Due to the continued presence of the concrete training wall, this alternative would not allow for the continuation of a restored floodplain bench through the dam area. However, it did include the removal of the eroding spillway. See Section 4.g for cost estimates.

4.a.iii. Alternative A3 – Removal of 94 linear feet.

Alternative A3 included removing more of the dam, a total of 94 feet, encompassing the embankment section, principal concrete spillway, and approximately 50 feet of the concrete training wall. This alternative included removal of the entire concrete and stone rubble wall and only leaves the concrete training wall in place. See Section 4.g for cost estimates.

4.a.iv. Alternative A4 – Removal of entire dam

Alternative A4 included removal of the entire visible portions of the dam plus 30 feet of the concrete training wall that is buried. This alternative allowed for the inclusion of a floodplain bench through the dam area. See Section 4.g for cost estimates.

4.b. Design Criteria

The 30% conceptual design plans were informed by field investigations, hydrologic & hydraulic analysis, and design criteria selected for this dam removal and restoration project. Design criteria included the following:

- Pilot channel slope within $\pm 25\%$ of the adjacent upstream and downstream reach slopes.
- Pilot channel geometry designed in line with the observed reference channel geometry, including bankfull width, bankfull depth, and floodplain connectivity.
- Pilot channel bed substrate and key pieces in line with the observed roughness and grain size distribution observed in the reference reach.
- Slopes from the floodplain benches to the existing grades not to exceed 2:1 (H:V) to promote bank stability and minimize erosion.
- Hydraulic modeling of proposed conditions results in reasonable design flows in terms of water depth, velocity, and stream power, indicating that the proposed conditions will not results in overly erosive flows through the pilot channel.
- Hydraulic modeling of proposed conditions results in lowered water surface elevations in the vicinity of the dam following dam removal.
- Hydraulic modeling of proposed conditions results in velocities through the pilot channel that support fish passage and satisfies fish passage criteria for high and low flows.
- Minimize potential damage to adjacent infrastructure by including grade controls throughout the pilot channel.

The following provides additional detail for the hydrologic and hydraulic design criteria listed above.

4.b.i. Hydrologic and Hydraulic Modeling of Design Flows

Stone staff used a gauge transfer technique to calculate design flows for the Hands Mill Dam watershed. First, Stone staff delineated the geographical region contributing flow to the site and determined the watershed size to be 6.65 mi². Then, Stone staff compared streamflow data from 3 USGS gauges within 50 miles of the site for analysis based on comparable watershed site, similar geology and surficial soils, length of period of record, and presence of obstructions to flow (ex. dam or withdrawal). At each gauge, a Log-Pearson Type III distribution was used to determine the 2-, 5-, 10-, 25-, 50- and 100-yr recurrence interval design flows. For each gauge, an additional hydrologic analysis was performed that compared records to data collected after 1970, to identify if the hydrology at each site was impacted by a recent shift in hydrologic regimes due to climate change. The resulting distributions were plotted and compared to the USGS StreamStats generated distribution.

The East Orange Branch, near East Orange, Vermont gauge (#01139800) was selected to determine peak flows at the site due to its long period of record (61 years), its comparable watershed size (8.8 mi²), proximity to the site, location along an unregulated stream and current status as an active gauge. Because the post-1970 flows were higher than those corresponding to the entire record at this particular gauge, the post-1970 flows were used for our analyses. The resulted peak storm flows for Jail Branch are provided in Table 2. The flow scenarios above were simulated using a hydraulic model described below.

Table 2. Summary of Peak Flows at Jail Branch

Recurrence Interval	Flow (ft ³ /s)
2	215
5	336

Recurrence	Flow
Interval	(ft³/s)
10	433
25	576
50	701
100	839

The proposed alternative lowers the modeled water surface elevation in the vicinity of the Hand Mill Dam for the modeled recurrence interval floods. Under existing conditions, the 100- and 500-year WSEs for the site are 1,265.28' and 1,266.29' respectively. Based on hydraulic modeling completed using USACE's HEC-RAS model, the WSEs for the 100- and 500-year are 1,264.24' and 1,265.33' respectively, and lower than existing conditions.

The hydraulic model output for proposed conditions, including channel velocities, water depth and stream power, are provided in Appendix B. Based on hydraulic modeling, the main channel velocities for the proposed design generally start to exceed the maximum permissible mean channel velocity for fine gravel (6 ft/s) bed materials at the 2-year recurrence interval storm. This is consistent with USFS stream simulation methods (2008) and indicates that natural sediment transport processes are supported under the proposed conditions, meaning that at the 2-year recurrence interval storm and above, the channel bed material will be mobile. Bank material sizing will be finalized during 100% design and will be sized to be stable up to the 100-year storm event.

High and low fish passage flows were also estimated to assess potential fish passage conditions at the site following dam removal. Daily streamflow data from the East Orange Branch gauge used for peak flow analysis were used to calculate the 5% and 95% exceedance flows (seasonal high and low flow). Seasonal high and low flows were calculated using daily streamflow data from the entire year and for daily streamflow data collected from September through November, when brook trout migration is likely. The proposed conditions hydraulic model was run using these flows to estimate channel water depth and velocity at fish passage flows and assess the ability of the proposed conditions to allow for aquatic organism passage and greater brook trout habitat connectivity. Modeling results indicate that the channel velocities and main channel water depth support adult brook trout passage and generally support juvenile brook trout passage under low, base, and high fish passage flows. While stream velocities exceed the maximum velocity for brook trout passage at some cross sections during peak flows, it is anticipated that brook trout will find refuge in slowly moving pools and eddies during these conditions.

Sept – Nov All Months Sept – Nov All Mo Fish Passage Flow Fish Passage Flow Channel Velocity ¹ Channel					
Flow	(ft ³ /s)	(ft ³ /s)	(ft/s)	(ft/s)	
High	15.6	31.7	2.11	2.65	
Base	4.0	6.7	1.58	1.68	
Low	1.2	1.3	1.19	1.22	

Table 3. Summar	v of Fish Passage	Flows and Modeled	Velocities for Pr	oposed Conditions	s at Jail Branch
rable of banning	, er i isn i assage	nons and modeled		oposea contantions	, at san branen

¹Average channel velocity at dam location after dam removal under Alternative A4

Hydrologic and hydraulic modeling efforts indicate that the chosen alternative satisfies the hydraulic design criteria for the project. Additionally, the 30% designs have been developed based on the channel design

criteria. Specific design elements will be finalized during 100% design to further satisfy the criteria listed in Section 4.b.

Schematic layouts for existing conditions and the selected alternative A4 are provided in Appendix A. Site plans were not developed for A2 and A3.

4.c. Environmental Impacts

An environmental and historical review of the site was completed in 2020. There are no known major environmental impacts for any of the alternatives considered, and few minor impacts are anticipated at this time. These minor impacts are summarized below. The EID for this project contains additional details and documentation.

4.c.i. Historical and Archaeological

The project area limit of disturbance includes, or is in proximity, to the following structures and buildings older than 50 years: 1) Hands Mill Dam, 2) 16 Woodchuck Hollow Road, 3) shed located at 39 Woodchuck Hollow Road, 4) 110 Woodchuck Hollow Road, 5) 273 West Corinth Road, 6) 53 Vermette Lane, and 7) 111 Vermette Lane. Of these properties, only the Hands Mill Dam is recommended for significance and National Register eligibility. Since the removal of the dam will result in an Adverse Effect, a Historic Resources Documentation Package and Historic Resource Mitigation work are included in the Scope of Work. The University of Vermont (UVM) Consulting Archaeology Program completed Historic Resource Review and Archeological Resources Assessment for the Hands Mill Dam site. The associated report is provided under separate cover.

There are three areas delineated as sensitive for pre-contact Native American Archeological sites within the vicinity of the proposed limit of disturbance. The extent of ground disturbance within the limit of disturbance encompasses 1.45 acres, largely within the stream and immediately in adjacent floodplain benches and is delineated with respect to the pre-contact Native American Archeological sites in Sheet 3 of the 30% design plans (Appendix A). Archeologically sensitive areas will be delineated in the field by a historic preservation consultant prior to construction. The total excavation volume is 13, 940 cubic yards, with an average excavation depth of 5.97 feet.

4.c.ii. Wildlife

Vermont Fish and Wildlife Department (VFWD) and the USFWS staff were consulted to identify listed species. On December 29, 2020 the District consulted the Vermont Natural Resource Atlas - Natural Heritage Inventory (NHI) which includes a database of rare, threatened, and endangered species and natural (plant) communities in Vermont. There are no mapped occurrences of rare, threatened, or endangered species within the proposed limits of disturbance. Additionally, VFWD correspondence with the District indicated no concerns for aquatic or terrestrial species. The dam site is approximately 6.67 miles from the nearest known occurrence of federally listed Northern Long-eared Bats. The project site is considered "potential summer habitat" but not "known summer or winter habitat" for Northern Long-eared Bats. There are 1213 acres of forested habitat within a mile of the project site and proposed vegetation clearing at the project site falls below threshold of concern (1%) for impact. VFWD supports the project to connect 14.7 miles of Eastern Native Brook Trout habitat.

4.c.iii. Vegetation

Stone identified trees greater than 3"DBH (size, location, species) likely to be removed (Sheet 5, Appendix A) and 30% Design Plans show mapped location of these trees in brown (Sheet 6, Appendix A). An estimated total of 13 trees may need to be removed to provide site access and removal of the dam. Larger trees will be

kept on site and used as root wads installed for bank stabilization (see 30% Design Plans Sheet 7 for practice details, Appendix A). Additionally, shrubs are growing on top of the dam and wetland species on top of the impounded sediment will be impacted by the regrading and floodplain bench installations completed for this project. A total of approximately 0.79 acres of vegetation will be affected by this project.

Wetlands delineation was completed by the VNRC in summer 2020 and wetland boundaries are included in the 30% Design Plans (Appendix A). The dam impounds a roughly 2-acre pond which has filled in over time, providing ideal habitat for submerged and emergent wetland plants. While there are no mapped wetlands from the National Wetlands Inventory within the project area, the DEC Wetlands Program determined that a regulated Class 2 wetland is present in the impounded area. Removal of Hands Mill Dam is likely to significantly alter the hydrology of these wetlands. DEC Wetlands staff performed an in-field bio-assessment to determine whether the species community was likely to tolerate longer periods of drought given the lower proposed flood elevation level and confirmed the presence of several groundwater seeps from uphill that may continue to keep the site wet in the absence of the dam. It is anticipated that the project will likely qualify as an Allowed Use under Section 6 of the Vermont DEC Wetland Rules. There is no alternative to operating within the floodplain and wetland as the dam is currently located in the floodplain and is surround by the wetlands. Project partners including the State Floodplain Manager and Wetlands staff have provided input on the designs to ensure construction activities minimize long-term impacts to the wetlands and floodplains.

4.d. Land Requirements

Not applicable, no easements are needed for dam removal.

4.e. Potential Construction Problems

Two portions of the design have been identified as potential construction challenges or problems. The first concerns the poor condition of the dam, and second involves the challenges of dewatering and completing construction in a dry channel.

Due to the degraded and fragile nature of the dam walls river right of the spillway, removal efforts will need to be focused and performed with care. The construction bid advertisement and specifications will clearly state that the dam is in a degraded condition and a construction sequence that will ensure a controlled removal of the dam will be required.

At this conceptual stage, it is expected that a coffer dam will be built just upstream of the dam and flows will be bypassed by gravity flow and pipes. During spillway removal, flows will be bypassed over or through the existing walls on river right. During wall removal, flows will be bypassed along river left over the former spillway. Final 100% designs will include a suggested flow bypass plan, however the contractor will be encouraged to submit their own plan that meets the specifications and permit requirements.

4.f. Sustainability Considerations

In addition to mitigating the current hazard presented by the Hands Mill Dam, the goals of this project include improving aquatic organism passage (AOP), restoring stream equilibrium, and improving water quality. The Jail Branch runs over 8 miles from the dam north and northwest into Barre, where it converges with the Stevens Branch; the Stevens Branch then flows a similar distance northwest where it flows into the Winooski River in the southeast portion of Montpelier. The Winooski River eventually empties into Lake Champlain. The removal of the Hands Mill Dam may lead to fish population and habitat improvements as well as water quality improvements locally within Jail Branch as well as downstream, following impounded sediment removal and restoration of natural sediment transport and other geomorphic processes.

The overall condition of the dam is poor, and it continues to deteriorate and progressively breach. Should the dam fail, vulnerable populations and infrastructure located adjacent to and downstream from the dam may be significantly impacted. Removal of the dam removes the potential for loss of life and lowers economic impacts due to dam failure and could be seen as a substantial economic and social benefit to the Town and its residents.

Additionally, as climate change brings more frequent and intense storm systems to New England, we expect that the risk of dam failure for Hands Mill Dam will most likely increase. Removing this significant hazard dam mitigates those future risks.

4.f.i. Water and Energy Efficiency

Not needed or applicable to design.

4.f.ii. Green Infrastructure

While the project does not involve traditional green infrastructure construction, the restoration of Jail Branch and installation of floodplain benches does have several in-stream and floodplain benefits. The existing floodplain provides some storage; however, the proposed designs allow for an additional 0.41 acres of floodplain storage. Connected floodplains serve many beneficial purposes, including increased storage volume, infiltration of stormwater runoff and filtering sediment and nutrients from the water column of floodplain flows. Additionally, as part of restoration, trees and riparian vegetation will be planted along the floodplain benches of the pilot channel, providing habitat and supporting evapotranspiration processes over the long-term.

4.g. Cost Estimates

Stone developed the Opinion of Probable Construction Cost (OPC) estimates for the four alternatives to the 15% design level and developed an OPC for the selected alternative to the 30% design level. The costs for each alternative are presented in Table 4 below.

	Typical	Life Cycle
	Engineering	Costs (\$)
Alternative	OPC (\$)	
Al	\$0	\$0
A2	\$340,100	\$181,843
A3	\$372,000	\$193,442
A4 (15%)	\$405,400	\$205,560
A4 (30%)	\$476,600	\$205,560

Table 4. Comparison of OPC Estimate for Alternatives

The 15% design OPCs listed in Table 4 include volumes for concrete and sediment removal, and other quantities estimated from the drawings and knowledge of the site, such as conceptual costs for survey layout, construction access, erosion prevention and sediment control measures, flow bypass measures, channel realignment, installation of grade controls, bank stabilization features and soil stabilization via grass seed and mulch. Stone used unit costs based on 2-year average unit cost data maintained by VTrans (http://vtrans.vermont.gov/cost-estimating), and unit costs from recent construction projects for similar bid items. Per standard cost estimating methodologies developed by the US Army Corps of Engineers, the OPC includes a 20% contingency to account for unforeseen construction costs related to site conditions, variability in pricing, etc. Costs for mobilization/demobilization are also included, estimated at 10% of the construction

costs. These costs do not include final design engineering fees, permitting, or bid phase services; however, those costs were provided in the final 30% design OPC for the chosen alternative, A4 (See Appendix C).

5. SELECTION OF AN ALTERNATIVE

During the preliminary design phase, the four alternatives described in Section 4.a were proposed to the stakeholder group. A1 was discarded because it failed to address the existing hazards, the potential for flooding and dam failure, which are expected to increase over time. A2 removed the principal concrete spillway but did not allow for full inclusion of a floodplain bench, and as a result it was discarded in favor of either A3 or A4, which both allow for floodplain restoration in addition to dam removal. Incorporating floodplain restoration into the selected design alternative alleviates both the flooding and dam failure hazards.

A3 and A4 were discussed in depth by the stakeholder group at the September 28, 2020 meeting with Stone and it was determined that due to the required excavation depths at the dam, the exposed portion of the concrete training wall along river right could not remain, as the excavation would most likely undermine the long-term stabilization of the wall. Therefore, partial removal of the dam under the A3 scenario would not be technically feasible. Stakeholder groups concurred that A4 was the best alternative to address all hazards of concern. Stone provided a September 2020 Interim Field Memo (Appendix D) summarizing these alternatives and the final 30% design plans described in this PER reflect the outcomes of the stakeholder discussion and support for Alternative A4. A letter from the DEC Dam Safety Division concurs with the selection of Alternative 4 from a safety perspective.

5.a. Life Cycle Cost Analysis

Life cycle costs were based on Attachment B to the RFP, and the United States Department of Agriculture Rural Utilities Service Bulletin 1780-2, Preliminary Engineering Reports for the Water and Waste Disposal Program, as provided on the state's State Revolving Fund website (https://dec.vermont.gov/waterinvestment/water-financing/srf/srfstep1/PER). Life cycle cost analysis (LCCA) consists of adding all initial and ongoing costs of the project over the life of the project, subtracting the salvage value of the project at the end of that time, and adjusting for inflation. With regards to annual costs, Stone assumed an annual cost of \$2,000 to account for vegetation establishment and/or management, over an assumed 20-year project life. We also assumed \$5,000 of 'repairs' every five years of the course of the project, accounting for any repairs or stabilization that may be required due to channel adjustments or any other unforeseen issues. The federal discount interest rate from OMB Circular A94 for 2020 of 0.25% was used for the analysis. Life cycle costs for each alternative are provided in Table 4 above and in detail in Table 5 below.

Table 5. Life Cycle Cost Analysis

Alternative	Total Project Cost ¹	PW Annual O&M Cost ²	PW Bank Repair Cost (20 yrs, 5 yr interval) ³	PW Salvage Value ⁴ (20 yrs, 0.25%)	Present Value	PW (Cost + Present Value)
Al	-	-	-	-	-	-
A2	\$287,696	\$38,969	\$19, 387	(\$164,209)	(\$105,853)	\$181,843
A3	\$314,719	\$38,969	\$19,387	(\$179,633)	(\$121,277)	\$193,442
A4	\$342,952	\$38,969	\$19,387	(\$195,748)	(\$137,392)	\$205,560

¹Capital Total Project Costs based on estimated construction cost in report

²Present Worth (PW) O&M costs based on estimated O&M cost in report

³PW Bank Repair Costs (5 yr interval)

⁴Estimated PW Salvage Value based on OMB Circular No. A-94 rate

⁵Present Worth of Salvage Value

5.b. Non-Monetary Factors

Alternative A4 was selected over other alternatives due to the depth of sediment removal directly behind the dam (approximately 14' deep) and the need to remove most of the concrete training wall due to long-term stability concerns. Besides the length and extent of dam removal, all other project components were the same across each alternative. Additionally, alternative A4 allows for channel and floodplain restoration within the vicinity of the dam. The ecological and hazard mitigation benefits associated with channel and floodplain restoration are not captured in the life cycle cost analysis.

6. PROPOSED PROJECT (RECOMMENDED ALTERNATIVE)

It is recommended that the Town move ahead with Alternative A4 at this time. The preliminary project design and financial impacts of the preferred alternative are discussed in this section.

6.a. Preliminary Project Design (Dam Removal and Restoration)

<u>Dam Removal</u>. The 30% design plans for the proposed alternative include the removal of approximately 165 linear feet of the dam, plus 30 linear feet of the buried dam, totaling approximately 453 CY of material. Additionally, large bed material that has accumulated downstream of the dam will be removed. No bedrock will be removed as part of dam removal. The potential limits of structures will be confirmed by the Contractor. See Sheet 5 in Appendix A for Dam Demolition plans.

<u>Pilot Channel Construction</u>. The limits of the proposed channel restoration and pilot channel construction are from station 5+08 to 14+00. The overall slope of the pilot channel is 2.1%, with approximately 1' elevation drops included at proposed step locations. Steps have been incorporated to provide channel bed grade control and channel stability in the vicinity of residential properties and provide the needed elevation drop through the pilot channel. The pilot channel bankfull width will be approximately 31 ± 2 feet. Existing tree fall in the project vicinity and trees removed to allow for site access will be used as wood additions and bank stabilization practices. See Sheets 6 and 7 in Appendix A for additional details on pilot channel design and construction.

<u>Floodplain Bench Construction</u>. The proposed design includes the construction of a 30 ft wide floodplain bench along river left of the pilot channel. The floodplain bench will be tied into existing grades along its extents. The slope from existing grade to the floodplain bench will be approximately 2:1 with a varying width. The slope of the floodplain bench toe to top of bank will be approximately 5%. Live stakes, fascines, vegetation and stabilization measures from top of bank to existing grade will be determined in 100% designs. Along river left, the 30% designs include a proposed tie-in to existing topography with slopes varying between 1:1 and 2:1.

<u>Ancillary Components</u>. Ancillary components of the design include site access, haul out of materials, bypass pumping, and erosion and sediment control. Primary access for pilot channel construction and sediment haul out will be off West Corinth Road (Appendix A). The Contractor will provide an Access and Material removal Plan to be approved by the Engineer prior to mobilization, and the Contractor will grade and create a temporary ramp into the floodplain to be restored following dam removal and channel and floodplain work.

6.b. Project Schedule

To date a 30% design and preliminary engineering study has been completed, along with a review of potential historic and archeological resources. The following schedule assumes that an Environmental Assessment is not required. If an EA is required, construction is expected to be completed in 2023. Throughout 2021 the District expects to finalize a 100% design plan, coordinate further public outreach and solicitation of

comments, apply for and secure matching funds, perform a Phase 1 archeological study (and a Phase 2 archeological study, if determined to be necessary), and secure local permits. If an EA is not required, all procurement will occur in February - May 2022 with field work and construction launched by Summer 2022. Planting will take place in September – October 2022. Annual O&M tasks will be conducted for a period of three to five years following the completion of construction. Bank sloughing monitoring will take place for a minimum of five years, and the need for such monitoring will be reassessed at that time.

	2021						2022															
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
100% Design																						
Permitting																						
Community outreach																						
Construction																						
Planting																						

Table 6. Project Schedule

6.c. Permit Requirements

The following permits are anticipated to be required for the project:

- Local Permits
 - State Floodplain Permit –or– Municipal Flood Hazard Permit
- State Permits
 - Stream Alteration
 - Chapter 43 Dam Order
 - Stormwater Construction Discharge Permit (if disturbing more than 1 acre of land)
 - Wetlands clearance (anticipated Allowed Use under Section 6 of the Vermont Wetland Rules)
 - 401 Water Quality Certificate (but not required if project qualifies for Corps VT General Permit)
 - State Historic Preservation Office concurrence
 - Act 250 (will be explored in 100% designs)
- Federal Permits
 - US Army Corps of Engineers Vermont General Permit, Category 2

6.d. Sustainability Considerations (if applicable)

6.d.i. Water and Energy Efficiency

Not needed or applicable.

6.d.ii. Green Infrastructure

Not needed or applicable.

6.e. Total Project Cost Estimate (Engineer's Opinion of Probable Cost)

The Total Project Cost estimates for Alternatives A4 is provided in Appendix D. The cost estimates provided include standard percentage allowances for a 20% contingency.

The 30% design OPC provided in Appendix D include volumes for concrete and sediment removal, and other quantities estimated from the drawings and knowledge of the site, such as conceptual costs for survey layout, construction access, erosion prevention and sediment control measures, flow bypass measures, channel realignment, installation of grade controls, bank stabilization features and soil stabilization via grass seed and mulch. We used unit costs based on 2-year average unit cost data maintained by VTrans (http://vtrans.vermont.gov/cost-estimating), and unit costs from recent construction projects for similar bid items. Per standard cost estimating methodologies developed by the US Army Corps of Engineers, the OPC includes a 20% contingency to account for unforeseen construction costs related to site conditions, variability in pricing, etc. Costs for mobilization/demobilization are also included, estimated at 10% of the construction costs. Costs for final design, permitting and bid phase service fees are also included.

6.f. Annual Operating Budget

The Town, as the owner of the property, will have primary responsibility over the annual operating budget. For this dam removal and floodplain restoration project, the annual operating budget largely consists of monitoring since all dam infrastructure will be removed from the property. An itemized annual operating budget is provided below.

6.f.i. Income

It is assumed that funds for any annual monitoring labor will come from the Town's annual public works maintenance budget. Funds for reseeding or replanting may come via restoration funding through the District or other entity.

6.f.ii. Annual O&M Costs

The annual O&M costs for the project were estimated by dividing the total monitoring and stewardship costs by the expected project useful life. The total cost for replanting materials, vegetation monitoring, replanting labor, and invasive management is \$7,308. The project useful life used for the FEMA Benefit Cost Analysis (BCA) was 30 years, or the default project useful life for restoration projects. The annual O&M cost over the project useful life is \$244; however, it should be noted that a majority of the monitoring and replanting work will take place in the first three years after construction. The total estimated cost for bank monitoring during the first five years after construction is \$4,000, assuming 8 hours of monitoring work per year at a typical professional hourly rate of \$100.

6.f.iii. Debt Repayments

Not applicable.

6.f.iv. Reserves Not applicable.

7. CONCLUSIONS AND RECOMMENDATIONS

The alternatives analyzed for this project varied in scope from no action to full dam removal. Given the existing condition of the dam, potential for mitigating a significant hazard, and opportunity to increase connectivity for brook trout habitat and floodplain restoration, alternative A4 is recommended as the proposed alternative. Further details regarding design components will be determined during the development of 100% designs for the project. Additional field work and analysis will be completed as needed to develop the 100% design.

8. Figures





Figure 1. Existing Dam Structure: Primary Spillway and Training Walls



Appendix A: 30% Design Plans

STONE ENVIRONMENTAL

HANDS MILL DAM REMOVAL **AT JAIL BRANCH** TOWN OF WASHINGTON, VERMONT

30% DESIGN **ISSUED: JANUARY, 2021**



DRAWN ON: 11/2/2020 DRAWN BY: GMB CHECKED ON: CHECKED BY: PROJECT NO: 20-007

| DATE DRWN CHK'D APP'D DESCRIPTION

PREPARED FOR: WINOOSKI NATURAL RESOURCES **CONSERVATION DISTRICT**

PREPARED BY: STONE ENVIRONMENTAL, INC.

Project Vicinity Scale: 1" = 4000'

DRAWINGS ARE HALF SCALE WHEN PRINTED ON 11X17



Project Location Scale: 1" = 400'



535 Stone Cutters Way / Montpelier / VT / 05602 / USA 802.229.4541 / info@stone-env.com / www.stone-env.com

DRAWING INDEX:

HEET	TITLE
	COVER SHEET
	SURVEY EXTENTS PLAN &
	LIMITS OF DISTURBANCE
	EXISTING CONDITIONS PLAN
	SITE ACCESS & MATERIAL REMOVAL PLAN
,	EXISTING DAM & DEMOLITION PLAN
i i	CHANNEL RESTORATION PLAN
	CHANNEL RESTORATION PROFILE & DETAILS



HANDS MILL DAM REMOVAL AT JAIL BRANCH COVER SHEET

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Limits of Disturbance							
Point Ta	able						
Latitude	Longitude						
44.105868	-72.430835						
44.106068	-72.428349						
44.105635	-72.426226						
44.104637	-72.426656						
44.103929	-72.427335						
44.104311	-72.428325						
44.104845	-72.429264						
	its of Dist Point Ta Latitude 44.105868 44.105635 44.104637 44.103929 44.104311 44.104845						

Legend



— 1280 — Major Contour — 1275 — *Minor Contour* — Edge of Road



EXAMPLE 1 Proposed Limits of Disturbance Proposed Limits of Disturbance Point



HANDS MILL DAM REMOVAL AT JAIL BRANCH SURVEY EXTENTS PLAN AND LIMITS OF DISTURBANCE WASHINGTON VERMONT





Legend

\triangle	Survey Control Point
— 1280 —	Major Contour
<u> </u>	Minor Contour
	Parcel Boundaries
	Edge of Road
••••••••	Guard Rail
OHU	Overhead Utility
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Vegetation Line
9	Tree
	River Top of Bank (OHW)
*******	Existing Wetland (See Note 6)
$+ \frac{1277.38}{12}$	Thalweg Spot Elevations
ں ' ک	Utility Pole
•	Manhole
0	Sanitary Manhole or Septic Cover
0	Well
۲	Vent
¥	Hydrant
⋈	Water Valve
36" CMP	Stormwater Pipe
<b></b> • <u></u> • <u>_</u>	Stormwater Swale
● <i>P</i> -6	Sediment Probing Location
HM-S1	Sediment Sampling Location
▲ HM-FP1	Floodplain Boring Location
	Archaeological Sensitive Areas

**EXAMPLE 1** Proposed Limits of Disturbance

# Survey Notes:

- 1. The vertical datum refers to NAVD88. Horizontal datum refers to Vermont State Plane Grid NAD83. Contour interval = 1 foot.
- 2. Contours were created using two sources of data: 1) a topographic survey of the channel bed, banks, floodplains and structural features collected by Stone Environmental (see Note 3 below), and 2) LiDAR data of upland features, obtained from the Vermont Center for Geographic Information.
- 3. Site survey was performed on August 11 and 12, 2020 by Gabe Bolin, PE, of Stone Environmental, Inc. using a Stonex S900 GPS base and rover.
- 4. Survey data provided in these plans do not represent a boundary survey.
- 5. Utility locations shown on this plan should be considered approximate. Contractor is required to verify utility locations prior to work.
- 6. Wetland boundaries shown on this plan were delineated by Karina Dailey of the Vermont Natural Resources Council (VNRC) on October 8, 2020. The wetland delineation was performed in accordance with the U.S. Army Corps of Engineers Wetland Delineation Manual, Technical Report Y-87-1, January 1987, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0), January 2012, and Section 3.2 of the Vermont Wetland Rules.
- Archaeological sensitive areas identified by the University of Vermont Consulting Archaeology Program, October, 2020.



HANDS MILL DAM REMOVAL AT JAIL BRANCH EXISTING CONDITIONS PLAN



DRAWN BY: GMB CHECKED ON: CHECKED BY: PROJECT NO: 20-007

1 inch = 40 feet (1:480)

535 Stone Cutters Way / Montpelier / VT / 05602 / USA 802.229.4541 / info@stone-env.com / www.stone-env.com

# Legend

${\bigtriangleup}$	Survey Control Point
— 1280 —	Major Contour
<u> </u>	Minor Contour
	Parcel Boundaries
	Edge of Road
•••••••••••••••••••••••••••••••••••••••	Guard Rail
OHU	Overhead Utility
~~~~~~	Vegetation Line
G	Tree
	River Top of Bank (OHW)
******	Existing Wetland
$+ \frac{1277.38}{12}$	Thalweg Spot Elevations
്പ	Utility Pole
Θ	Manhole
0	Sanitary Manhole or Septic Cover
0	Well
۲	Vent
*	Hydrant
凶	Water Valve
36" CMP	Stormwater Pipe
	Stormwater Swale
● <i>P</i> -6	Sediment Probing Location
HM-S1	Sediment Sampling Location
▲ HM-FP1	Floodplain Boring Location
	Archaeological Sensitive Areas
	Proposed Limits of Disturbance
	Proposed Site Access Route
	Proposed Timber Mats

Site Access & Material Removal Notes:

- 1. Utility locations shown on this plan should be considered approximate. Contractor is required to verify utility locations prior to work.
- 2. The suggested site access shown on this sheet is an example and for the purposes of project bidding.
- 3. The Contractor shall submit an Access and Material Removal Plan for approval by the Engineer prior to mobilization. The plan can follow the suggested route, or vary based on revised project sequencing. Overall, the Plan will be the Contractor's plan that meets all permit requirements and is subject to approval by the Engineer. See specifications.



HANDS MILL DAM REMOVAL AT JAIL BRANCH SITE ACCESS & MATERIAL REMOVAL PLAN

WASHINGTON





Dam Demolition Plan Notes:

- 1. Potential limits of structures, as indicated on this sheet are based on surveys, probing data and assumed geometry of structures, and are therefore unconfirmed and should be verified by the contractor.
- 2. Note that there will be no removal of bedrock at the dam and throughout the extent of the project.



HANDS MILL DAM REMOVAL AT JAIL BRANCH EXISITNG DAM & DEMOLITION PLAN

WASHINGTON





${\bigtriangleup}$	Survey Control Point
— 1280 ——	Major Contour
<u> </u>	Minor Contour
	Parcel Boundaries
	Edge of Road
•••••••••••••••••••••••••••••••••••••••	Guard Rail
OHU	Overhead Utility
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Vegetation Line
6 6	Tree (Brown Color Indicates to be Removed
	River Top of Bank (OHW)
	Existing Wetland (See Note 6)
	Thalweg Spot Elevations
് <b>പ</b>	Utility Pole
Θ	Manhole
0	Sanitary Manhole or Septic Cover
®	Well
۲	Vent
¥	Hydrant
凶	Water Valve
36" CMP	Stormwater Pipe
	Stormwater Swale
	Archaeological Sensitive Areas
	Proposed Limits of Disturbance
	Extents of Ground Disturbance
1276	Proposed Contours
	Dam Removal Line

# Channel Restoration Plan Notes:

- Contractor to clear and grub as necessary to provide access, remove dam and construct bank stabilizations (Item 201.10).
- 2. Contractor to install topsoil and seed along disturbed floodplains and other areas of disturbance per the direction of the Engineer.
- 3. See the 'Typical Channel Cross Section' on Sheet 6 for a depiction of the pilot channel cross section to be constructed per the extents shown on this sheet
- Final channel and floodplain grading associated with the limits of pilot channel construction and bank stabilizations shown on this plan may be further revised in 100% design plans.



HANDS MILL DAM REMOVAL AT JAIL BRANCH CHANNEL RESTORATION PLAN

WASHINGTON



# Appendix B: Hydraulic Modeling Results

STONE ENVIRONMENTAL



Hands Mill Dam Removal - Longitudinal Profile for Peak Flows







# Appendix C: 30% Design OPC



# Hands Mill Dam Removal Alternative A4 - 30% Design OPC Stone Environmental, 1/2021, V4.2

ITEM #	ITEM	AMOUNT	UNIT	UNIT COST	TOTAL
General					
1	SURVEY LAYOUT	1	LS	\$4,000.00	\$4,000.00
2	CONSTRUCT ACCESS	1	LS	\$20,000.00	\$20,000.00
3	EPSC MEASURES	1	LS	\$15,000.00	\$15,000.00
4	FLOW BYPASS AND DEWATER SITE	1	LS	\$20,000.00	\$20,000.00
Dam Remo	oval				
5	DEMO DAM AND HAUL OUT STONE	453	CY	\$220.00	\$99,660.00
Channel R	estoration				
6	COMMON EXCAVATION (CHANNEL AND FLOODPLAIN BENCHES)	13940	CY	\$7.50	\$104,550.00
7	SEDIMENT HAUL	13386	CY	\$7.50	\$100,395.00
8	CHANNEL REALIGNMENT	1	LS	\$15,800.00	\$15,800.00
9	INSTALL STONE STEPS, POOLS AND ROOTWADS	1	LS	\$25,000.00	\$25,000.00
10	PLACE SEED, MULCH AND FASCINES	1	LS	\$10,000.00	\$10,000.00
			CONSTR	UCTION TOTAL	\$414,405
		MOBILIZATION / D	EMOBIL	IZATION (10%)	\$41,441
		CONSTRUCTIO	ON CONT	TINGENCY (5%)	\$20,720
		TOTAL (ROUNI	DED TO I	NEAREST \$100)	\$476,600

Design, Permitting and Construction Services FINAL DESIGN & PERMITTING (~9%) \$36,661

BID AND CONSTRUCTION PHASE SERVICES (~5%) \$22,018

# Appendix D: Interim Field Work and Modeling Summary Memo





September 23, 2020

To: Gianna Petito, District Manager, Winooski Natural Resources Conservation District

From: Gabe Bolin, PE, Meghan Arpino, Stone Environmental, Inc.

# Μεмο

Stone Project No. 20-007 Subject: Hands Mill Dam Removal – Field Investigations and Modeling Summary Memo

Stone Environmental, Inc. (Stone) has completed data review, field investigations, modeling and concept plan development at the Hands Mill Dam as part of the overall 30% design effort. This memo provides a summary of these efforts, including data sources, methods and results of field investigations and modeling, and a concept plan for discussion.

# 1. Introduction

The Hands Mill Dam is a partially breached stone and concrete structure located along the Jail Branch in Washington, Vermont. The Jail Branch runs over 8 miles from the dam north and northwest into Barre, where it converges with the Stevens Branch; the Stevens Branch then flows a similar distance northwest where it flows into the Winooski River in the southeast portion of Montpelier. The watershed area draining to the Hands Mill Dam location (at 44.10569, -72.43000) is 6.65 mi² (StreamStats, 2020). The majority of the watershed is forested, with only 3.7% of the watershed considered developed land (NLCD 2011 classes 21-24; StreamStats, 2020).

The visible portions of the dam measure approximately 12-16 feet high and 165 feet long. While the original construction date of the dam is unknown, the Town's Hazard Mitigation Plan states that construction of the dam was completed in 1860 (Town of Washington, 2013). The dam was reconstructed after the November 1927 flood, which included construction of new concrete components at that time. It was reported that a Mill was onsite as early as 1866.

The dam is a jurisdictional dam, meaning it impounds more than 500,000 cubic feet of water and sediment, and is therefore regulated by state statute 10 V.S.A. Chapter 43 under the state's Dam Safety Program. The dam is classified by the state as a Class 2, "Significant Hazard" dam. Per the latest Dam Safety Inspection Report (VTDEC, 2016), 'Significant hazard potential category structures are those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads, or cause interruption of service of relatively important public utilities. The potential for loss of life is few and the potential economic loss is appreciable'. A revision to the Dam Safety Rules is now in effect as of August 1, 2020 with adoption scheduled for July 2022. Under these new rules, due to the potential loss of life associated with this

dam, the status may be revised to 'High Hazard'. The current condition of the dam is poor, with continued deterioration and continued breaching during significant storm events. The current condition of the dam is discussed further under Task 2-1.

# 2. Field Investigations

# Task 2-1: Review of Existing Data

Our review of existing dam data was limited to the data and files the Winooski NRCD had collected as part of the RFP process (Attachment G), septic system information for the house directly adjacent to the dam on river left, at 16 Woodchuck Hollow Road, also provided by the Winooski NRCD and the Towns Hazard Mitigation Plan. The Attachment G data consisted mostly of VTDEC Dam Safety Inspection Reports, dating from 2016 back to 1953. The VTDEC is expected to have a new 2020 Dam Safety Inspection Report available prior to the end of the year. Despite efforts to find additional documents online via internet searches, no additional data was found.

A review of the Dam Safety Inspection Reports indicates continued deterioration of the dam over the decades, specifically the downstream wall, crest of the dam and the concrete training wall. The following provides a summary:

- <u>Downstream Wall</u> The wall is made up of concrete and large stones. Loss of stones was reported frequently over multiple reports. Reports of scour to the left of the spillway were also mentioned frequently. In the 2013 inspection report, it was reported that this area has '*deteriorated rapidly, probably as a result of TS Irene and recent high water*'.
- <u>Dam Crest</u> The crest was consistently reported to be in poor condition. Reports stated it was covered with vegetation and signs of overtopping, erosion and evidence of a partial breach near the mid-section with fallen concrete at the dam bottom, in line with this location.
- <u>Concrete Training Wall</u> The training wall to the right of the dam was reported as being consistently covered with vegetation with cracking visible at exposed sections.
- Reports of the dam in 'poor' or 'weakened' condition date back to inspections from 1953. The 1953 report states that 'the north wing wall has fallen down and water has started to erode the earth embankment behind it', with additional reports of seepage through the south abutment.
- Suggestions by the state for repairs date back to the 1953 report, and suggestions for retaining a professional engineer to develop plans to either reconstruct or remove the dam date back to 2001.
- A hydrologic study in a 1975 report indicated that the 'East Orange Brook' watershed was used as a reference to develop peak flood estimates for recurrence interval storm events at the dam. Similarly, Stone selected the East Orange Branch USGS gauge for our hydrologic analysis; see Task 3.

### Task 2-2: Infrastructure Stability Analysis

Stone conducted a preliminary infrastructure inventory and analysis using knowledge of the project site, publicly available information and state culvert and bridge inventories. Utilities investigated included stormwater, drinking water, wastewater and overhead utilities (i.e. electric and telecom), while infrastructure investigated included bridges, roadways, rights-of-ways and the dam itself. Following our review of this data, a total of four infrastructure items were thought to require additional review with respect to dam removal and potential stability and/or conflict issues. A summary of these items is provided in Table 1 below. The bridge dimension data provided in the table was obtained from the state inventories.

Item	Location	Location Relative to Dam	Ownership	Notes	Vulnerability
West Corinth Road Bridge	Jail Branch at West Corinth Road	Upstream	Town	Span 15', width 28' (in direction of flow)	Low
Woodchuck Hollow Road Bridge	Jail Branch at Woodchuck Hollow Road	Downstream	Town	Span 18', width 26' (in direction of flow)	Low
Roadways	West Corinth Road and Woodchuck Hollow Road	Those directly adjacent to project area	Town	West Corinth Rd. newly paved; Woodchuck Hollow Rd. gravel	Low
Water Hydrant	Corner of West Corinth Road and Vermette Lane	Upstream	Unknown	No record of potable water system in state GIS databases	To Be Determined

### Table 1. Infrastructure of Interest Within the Project Vicinity

As part of the geomorphic survey, (Task 2-4) Stone staff collect bankfull width measurements of Jail Branch in a reference reach approximately 100 feet upstream of the West Corinth Road bridge. The average bankfull width was 23.4 feet. Considering the span of 15 feet listed in the state bridge inventory, the bridge span is 64% of the average bankfull width. The state standard for a road-stream crossing on this sized stream requires a crossing to be 100% of the bankfull width of the upstream reach that is out of the influence of the culvert. Although undersized when considering this standard, there are no obvious signs of significant scour along the bridge abutments under the bridge, and no significant signs of erosion on either bank directly downstream of the bridge. Additionally, at this preliminary stage we do not expect removal of impounded sediment behind the dam to result in any significant stream bed adjustments at this bridge, therefore we do not expect any stability or conflict issues at this bridge.

A similar analysis was performed for the Woodchuck Hollow Road bridge. The average bankfull width measurements along the main channel of Jail Branch, upstream and downstream of the dam was 33.1 feet, as

discussed in Task 2-4. Considering the span of 18 feet listed in the state bridge inventory, the bridge span is 54% of the average bankfull width. This road-stream crossing is even more undersized than the West Corinth Road bridge, however similar to that bridge, Stone did not observe any signs of significant scour or erosion along the bridge abutments or directly downstream of the bridge, respectively. The reach just upstream of the bridge is well armored with natural cobble and boulders, and a masonry wall defines the left bank just upstream of the dam. Bedrock was also observed underneath the bridge right at the bridge outlet. These hard structures and natural armoring may be two reasons why significant erosion is not observed in the immediate area. Although, hard structures such as these typically do not dissipate flow energy well, and these structures might be contributing to erosive energy conveyed further downstream, beyond the bridge. This theory would be supported by the channelized, entrenched nature of the reach a few hundred feet downstream of the bridge. As discussed under Task 2-4, entrenchment ratios were calculated for reaches throughout the project area and this particular reach had the lowest ratio, indicating that the reach is significant disconnected from adjacent floodplains. Overall, at this preliminary stage, stability or conflict issues with respect to dam removal are not a concern at this bridge, as we do not expect dam removal or pilot channel creation to result in any significant bed adjustments or scour at this bridge.

The vulnerability and potential impacts to adjacent roadways and their embankments were also considered as part of this task. Because the floodplain associated with the impounded area butts up to both road embankments associated with West Corinth and Woodchuck Hollow Roads, this assessment was warranted. Having developed a preliminary limits of disturbance, and having reviewed a range of potential pilot channel slopes that provides insight as to the extent of impounded sediment removal, at this time we do not expect dam removal, impounded sediment removal or pilot channel creation to pose any stability or conflict issues with these roadways. We believe it is possible that the current elevations at the embankment toe of slopes will remain the same, and the project work can 'blend' into the limits of these roadways. We also do not expect there to be any significant channel work required where Jail Branch meanders into Woodchuck Hollow Road, at stations 4+00 to 5+00 (i.e. just upstream of the Woodchuck Hollow Road bridge), as shown on Sheet 2 (note that Sheets 1-4 are attached to the end of this memo). If any channel modifications are made at this location, it may include small adjustments to elevations as the pilot channel is expected to tie in to the existing channel in this area.

The final infrastructure item of concern at this time is the hydrant located at the corner of West Corinth Road and Vermette Lane. The hydrant is of an older type, and state drinking water infrastructure GIS data shows no potable water system in the area. Regarding the Town's municipal water system as outlined in the Washington Town Plan (Washington Planning Commission, 2013), '*Water from the* [town] *well is pumped up the Corinth Road to a 70,000-gallon concrete reservoir where it is gravity feed back to the distribution system*'. It still remains to be seen if there is any water system pipe running along West Corinth Road in the vicinity of the project. Stone has contacted the Town about this issue. While we expect that any watermain line would run within the right-of-way of the road and not within the limits of the impoundment, we'll plan to obtain information regarding the hydrant and system prior to finalizing 30% designs.

The following provides a summary of data sources that supported the assessment performed under this task. The majority of the information was obtained from the Vermont Center for Geographic Information (VCGI):

- <u>Ortho imagery</u> 0.3 meter Color and Color Infrared (4-band) orthoimagery (leaf-off) from 2018 VT Orthos, obtained from the VCGI Imagery Program
- <u>LiDAR</u> 0.7 meter Digital Elevation Model, hydro flattened derived from 2014 lidar data (QL2), obtained from the VCGI LiDAR Program
- <u>Stormwater, Water and Wastewater utilities</u> Stormwater Infrastructure (point, area and line features); Stream Crossings; Wastewater Infrastructure (point and line features); Drinking Water Infrastructure (linear features) from the VANR GIS, Open Data website
- <u>Bridges</u> Bridge inventories available from the state (<u>https://vtculverts.org/</u>)

# Task 2-3: Vegetation Survey

During the topographic survey, Stone developed an inventory of trees over 3" diameter at breast height (dbh) within the limits of disturbance that may require removal during construction of the project. Table 2 provides a summary of those trees. Note that at this time the project design is at the conceptual level (i.e. 15% design level) and certain trees along the boundary of the limits of disturbance may or may not need to be removed, depending on the details of the final design. Because of this current uncertainty, the column 'Likelihood of Removal' has been included to capture the possibility of removal relative to final design.

#	Species	Size (dbh, inches)	Location	Likelihood of Removal
1	Willow	32	River left, near parking area	high
2	White Birch	6, double	On top of dam	high
3	Pine	24	River left, on 16 Woodchuck Hollow Road property	medium
5	Maple	18	River right, $\sim$ station 9+00	medium
4	Pine	24	River left, $\sim$ station 10+00	high
6	Pine	20	River right, $\sim$ station 10+50	low
7	Oak	20	River right, $\sim$ station 11+50	low
8	Pine	18	River right, $\sim$ station 13+50	low
5	Maple	18	River right, ~station 13+75	low
10	Maple	16	River right, $\sim$ station 14+00	low

### Table 2: Vegetation Survey Summary

Approximate locations of these trees are provided on Sheet 2. Some of the details in Table 2 above require refinements. Due to limited time during the topographic survey and other field work, and due to difficulty in accessing some of these trees due to dense floodplain vegetation, some of the information in this table is an estimate (i.e. dbh, species, etc.) and/or has been acquired by remote surveys. Refinements will take place prior to completion of 30% designs.

### Task 2-4: Geomorphic Survey

Stone completed a limited geomorphic assessment of Jail Branch upstream and downstream of the dam, and along a reference reach on September 4th, 2020.

### **Basic Assessment**

The first portion of the assessment consisted of collecting bankfull width and depth measurements upstream and downstream of the dam to determine entrenchment ratios of Jail Branch throughout the project area, and get a general sense of geomorphic conditions within the project area. Observations and measurements were obtained at six locations, three upstream and three downstream of the dam. The results of this initial geomorphic assessment are presented in Table 3. Station data is provided in Sheet 2.

Location	Distance Upstream from Dam (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Flood- Prone Width (ft)	Entrenchment Ratio	Channel Description
US3	13+35	43.5	3.4	337.5	7.8	pool head
US2	10+12	28.6	4.0	494.0	17.3	riffle
US1	9+27	32.7	4.1	280.2	8.6	riffle
DS1	4+32	30.4	5.3	145.2	4.8	step
DS2	2+28	28.6	6.1	78.3	2.7	riffle
DS3	1+78	35.0	3.3	47.0	1.3	riffle

Table 3: Initial Geomorphic Assessment Results - Project Area

Flood-prone widths were measured at an elevation equal to twice the bankfull depth at each location, using LiDAR and knowledge of the site. Entrenchment ratios were calculated by dividing the flood-prone width by the bankfull width. Per the Rosgen Stream Classification Technique (USDA, 2007) entrenchment ratios of greater than 2.2 are considered 'Slightly Entrenched', and are generally well connected to adjacent floodplains. The lowest entrenchment ratio was recorded at the furthest downstream location (DS3), where the channel is deep and channelized for a few hundred feet downstream of the Woodchuck Hollow Road Bridge. Moving upstream from this location, channel entrenchment is gradually reduced and the channel is more connected to adjacent floodplains. Overall, floodplain connection upstream of the dam is greater than floodplain connection downstream of the dam.

The average of bankfull width and depth measurements provided in Table 3 is 33.1 feet and 4.4 feet, respectively. The largest bankfull width value of 43.5 feet measured at the most upstream location (US3) could be considered exaggerated since it is just downstream of the junction between Jail Branch and the largest tributary to Jail Branch, discharging from the northeast. This junction is suspected to be a dynamic area during high flow events, with flow and sediment transport highly influencing bank full geometry in the immediate area. The average bankfull width of 33.1 feet matches well with the calculated bankfull width based on the Vermont Regional Hydraulic Geometry Curves, where a width of 30 feet, depth of 1.8 and an area of 51 ft² were calculated (VTANR 2006). The average bankfull depth of 4.4 feet does not compare well with the regional curves estimate, however. One potentially theory for this is that during large storm events, the presence of the dam causes backwater effects and a slowdown of floodplain waters in the impoundment, which has led to excessive settling of sediments on floodplain surfaces overtime. The 'building up' of those surfaces has increased floodplain surface elevations resulting in deeper bankfull depths.

### Reference Reach Assessment

Additional geomorphic assessment work was performed in a reference reach. Stone staff identified reference reach conditions approximately 100 feet south of the culvert at Jail Branch and West Corinth Road during the topographic survey. From that point, the reach extends another 200 feet upstream along Jail Branch. Upon review of all reaches of Jail Branch and tributaries, this section of stream was selected as a reference because it was clearly out of the impounded area, it wasn't overly impacted by anthropogenic impacts, it visually seems to be in equilibrium and it includes a fair amount of habitat features in the bed (pools, backwatered areas, favorable bed substrate, etc.). On Sheet 1, the reference reach extends from about station 20+00 to 22+00 (south of West Corinth Road, and potentially extending past this station).

Stone staff characterized the stream bed, collected bankfull measurements and collected cross section data in the reference reach. Stream bed data included the delineation of bed habitat features (i.e. step, riffle, pool, run, etc.), bed feature length, width, elevation features and frequency. For instance, three pools were found within the reference reach, with an average length of 23', average width of 10.7' and max pool depth of 1.3'. The bed material within the pools consisted of 50% cobble with small boulders, and occasional large boulders providing cover and refuge for aquatic organisms. Key pieces, or small to large boulders that made up individual stone steps found in the reach, had an average intermediate measurement of 21 inches, among the 20 pieces that were measured. The roundedness of these stones ranged from rounded to angular, with the majority of pieces being rounded, while the embeddedness of the pieces in the stream bed range from 0 to 50% imbedded. Roughness boulders, or stones that aren't included in a bed structure but exist in a random nature throughout the stream bed, and tend to add more roughness to the channel, were also observed in the reference reach. They had an average intermediate measurement of 24.6 inches, a roundedness that ranged from rounded to sub-angular, and were imbedded in the channel within a range of less than 5% to 50%. Two

pebble counts were performed in the reference reach as well. The purpose of these counts is to characterize the gradation of the bed material, or distribution of different sized stones within the bed matrix. A plot of the count date as a grain size distribution is provided as Figure 1.

Bankfull measurements were collected in the reference reach. Similar measurements were also obtained in the unnamed tributary to Jail Branch, conveying flow from the northeast. Table 4 below provides a summary of bankfull measurements from each reach, along with averages. Note that while the unnamed tributary was not used as a reference reach, this tributary did exhibit reference reach characteristics and could be further investigated as a reference reach if needed, during Phase 2 design.

Reach	Location	Bankfull Width (ft)	Bankfull Depth (ft)
	BF1	25.2	2.33
Jail Branch	BF2	25.8	1.8
Reach	BF3	19.3	1.68
	Avg.	23.4	1.9
	TRIB-BF1	18.2	2.22
Unnamed	TRIB-BF2	17.9	1.84
Tributary	TRIB-BF3	20.2	1.68
	Avg.	18.8	1.9

Table 4: Initial Geomorphic Assessment Results – Reference Reach



Figure 1. Grain size distribution plots for two pebble counts in the reference reach along Jail Branch.

# Reference Reach and Pilot Channel Section

Cross section data was collected in the reference reach during the topographic survey. While the bankfull width and depth measurements at the reference reach were understandably smaller than those of the main channel discussed above in this section (due to a smaller watershed size), the reference reach section was 'scaled up', such that the bankfull width and depth of the pilot channel section match average bankfull dimensions for the main channel. While performing this scaling, Stone staff maintained the overall geometric ratios of the reference reach, specifically the depth from bottom bank to the overbank or adjacent floodplains. Reference reaches were well connected to adjacent floodplains, and this detail was maintained in the pilot channel section. Overall, the bankfull width set for the pilot channel cross section is  $29 \pm 2$  feet, while the depth was set to approximately 2.5 feet. This is consistent with calculations based on the Vermont Regional Hydraulic Geometry Curves discussed above.

A bankfull width 'range' and an approximate depth are proposed to incorporate a reasonable amount of variability in the design to simulate conditions in the natural environment, such that the project doesn't look 'constructed' following implementation. Variability in constructed channel width and depth should facilitate channel diversity, complexity of channel bedforms and ensure an abundance of aquatic habitat. The proposed pilot channel cross section is provided in Sheet 4 as the 'Typical Channel Cross Section'. Note that

at this time only one pilot channel cross section is provided since the types of lands along the overbank in the reference reaches is consistent over significant lengths of reference reach conditions (i.e. floodplain with little to no wetlands present along the overbank). Additional cross sections can be considered in Phase 2 if wetlands will be anticipated adjacent to the pilot channel.

## Task 2-5: Topographic Survey

Stone staff mobilized at the site on August 11 and 12, 2020 to perform the topographic survey. A GPS base and rover were used 1) to set control points throughout the project area to establish horizontal and vertical control, 2) to collect longitudinal profile and cross-section data upstream and downstream of the dam and 3) to collect details of structures such as the dam, bridges, infrastructure and utilities.

Stone established four control points throughout the site, all of which were established in the vicinity of the dam and downstream bridge. Locations and descriptions of control points are provided on Sheet 2 and were set in road pavement, at utility poles and at the downstream bridge headwall. As a quality control measure, Stone regularly checked back to control points to assess equipment precision and data accuracy. Any discrepancies found to be over 0.1 feet resulted in resurveying of relevant data.

The extent of the survey data is shown on Sheet 1. Approximately 2,200 feet of longitudinal profile was collected along Jail Branch, including reference reaches upstream of the site, down to a few hundred feet beyond the bridge at Woodchuck Hollow Road. Approximately 500 feet of longitudinal profile of the unnamed tributary to Jail Branch, conveying flow from the northeast was surveyed, along with two additional tributaries conveying flow from the west up to Vermette Road. Typical features collected as part of the longitudinal profiles specific to fish habitat included top and bottom of steps, pool head and tail crest, maximum pool depth, riffle head and tail, etc. Longitudinal profile data is used to define reach slopes, which is a primary dataset in designing the pilot channel; therefore a large amount of this data was collected as part of the survey.

Additional cross section data was collected along the main channel within the project area, including top of bank, bottom of bank, thalweg, bars and other bed features. The dam was surveyed and detailed, and roads and utilities were also located during the survey. Where Stone was unable to access land to survey, we combined our survey data with LiDAR data made available by the State.

Stone staff uploaded the survey data into AutoCAD to develop the project basemap, which included a 3dimensional surface (i.e. triangular irregular network, or TIN) of the project site and development of 1-foot contours based on the TIN. A longitudinal profile along the thalweg of the stream channel is provided on Sheet 4.

# Task 2-6: Sediment Probing

## **Probing Methods**

On August 26, 2020, Stone performed sediment probing within the impoundment, from directly behind the dam to approximately 130 feet upstream using an extendible steel tile rod. Probing was completed at 15 locations as shown on Sheet 3. At each location, the steel tile rod was advanced into the streambed by hand or driven into the streambed using a hammer, depending on the difficulty advancing the probe into the bed sediment. When the steel rod was unable to be driven further into the streambed, the nature of refusal, including resistance, vibrations, and audible cues, were noted.

To compare the probing depths to the bottom of the dam elevation and to ultimately assess the potential for AOP following dam removal, a temporary datum of 0.0' was set at the impoundment water surface. The bottom of the dam relative to this datum measured approximately 11-13' down, along the face of the dam. Therefore, at any probing location where we were able to drive 12' or more of rod under the water surface, we considered the tip of the rod to be approximately even with, or below, the bottom of the dam.

At each probing location, in addition to refusal data, the total rod depth from the water surface to refusal was measured and recorded. Water depths were also recorded at each location, in addition to positioning data used to plot the locations (see Sheet 3).

# **Probing Results**

Overall, exploratory probing provided insight into refusal elevations and the nature of refusal immediately upstream of the dam. The results at each location are summarized in Table 5.

Where vibrations and audible cues indicated refusal via bedrock at a few locations, a lack of refusal at other locations indicated either 1) the absence of bedrock and/or an AOP barrier or 2) a different type of material at depth that would require additional driving of the probing rod. At many of these locations, substantial hammering and effort would typically only result in a half inch, or inch advancement over time. And at a few locations that followed the thalweg, suction force (in the presence of muck) or resistance force (in the presence of sand/gravel) posed major challenges in retrieving the probing equipment, and therefore some explorations were abandoned for fear of losing equipment. When a probing location was abandoned, a new probing location was attempted close by in order to eliminate any data gaps.

Overall, Stone staff attempted to drive the probe to 12' below water surface to confirm a lack of bedrock and/or barrier at the estimated bottom of dam elevation. While the results in the table indicate that there seems to be a path upstream of the dam where bedrock and/or barriers are not present down to the bottom of dam elevation, it's important to understand that the probe diameter used for the explorations is approximately ½" in diameter and the accuracy of this data should be considered coarse, with limitations based on the equipment used and density of explorations.

Probe ID	Water Depth (ft)	Description	Height Above Dam Bottom (ft)
P-1		No data – equipment malfunction	
P-2		No data – equipment malfunction	
P-3	3.15	No refusal, hard sand layer (?), abandon	5.85
P-3-2	3.18	Refusal, boulder/bedrock	4.8
P-4	3.16	Refusal, boulder/bedrock	4.5
P-5	2.15	No refusal, muck, abandon	3.3
P-6	2.56	No refusal	-0.31
P-7	2.45	Refusal, no boulder/bedrock, but hard layer	8.45
P-8	0.92	No refusal	0.00
P-9	2.34	Refusal, sand/debris	3.98
P-10	1.75	Refusal, sand/debris	8.89
P-11	1.75	No refusal	3.08
P-12	0.37	Refusal, boulder/bedrock	1.94
P-13	2.32	No refusal, muck, abandon	3.14
P-14	1.4	No refusal	0.55
P-15	1.94	No refusal	0.27
P-16	2.05	No refusal	0.43

Table 5. Probing Results Upstream of Dam

### **Recommendations for Potential AOP**

Further inspection of the data indicates the path from P-6 and P-8 at the dam, extending upstream to P-15, P-16 and P-14 indicates that there are areas at depth with no obstructions at the bottom of dam elevation. It should be noted however, that explorations just upstream of the dam (i.e. 5-10 feet upstream) at locations P-7, P-9 and P-10 indicated refusal due to hard layers and/or debris. While probing results like this are expected along the perimeter of a dam, due to potentially variability in dam construction and dimensions, our probing efforts cannot confirm what the dam is directly built on. In other words, bedrock or an AOP barrier may still exist just under the dam structure or within a few feet of its perimeter. Confirmation of what the dam was built on can potentially be confirmed via ground penetration radar (GPR) surveys, or via dam removal during the construction phase. For the purposes of this conceptual memo, Stone has confirmed that there seems to be a path with no obstructions at the bottom of dam elevation, from about 15 feet behind the dam upstream approximately 125 feet, to the visible portion of the training wall along river right.

### Task 2-7: Impounded Sediment Characterization

### Impounded Sediment Volume Estimate

Stone estimated the volume of impounded sediment wedge behind the dam based on 1) the topographic survey data, 2) the probing data and 3) the use of the proposed pilot channel slope and section, as a proxy for the historical channel. The topographic survey data was used essentially as the existing, or current surface, while the probing depths and proposed pilot channel section was used to mimic the channel that existed prior to dam construction. We thought using the pilot channel slope and section as a proxy to the relic channel was feasible since it is set to a slope that is very similar to adjacent reaches, and also matches bankfull dimensions of adjacent reaches. This methodology should do a fair job in estimating the wedge of impounded sediment behind the dam, in the channel and immediate bank areas.

Additionally, in order to estimate the amount of impounded sediment that may have settled on relic floodplains, Stone made additional considerations. Upon inspection of the existing conditions surface provided on Sheet 1, there seems to be a substantial amount of floodplain along river left within the project area, while on river right the contours seem to slope gently from uplands towards the river right bank of the Jail Branch. While at this time we do not have data with respect to pre-dam floodplain elevations along either bank, one can assume that prior to dam construction, much of the natural floodplain area for this system within the project area existed along river left, and due to the impounding nature of the dam, over approximately 160 years this natural floodplain filled in with sediment to some degree, similar to the channel. In order to account for settling of sediments not only in the channel, but in the floodplains as well, for this conceptual calculation Stone revised the pilot channel cross section to include an 80 foot wide floodplain bench. Using the pilot channel slope and this altered section as a proxy for the historical channel and floodplain area, for the purposes of this calculation only, we estimate that a total of 14,300 CY of impounded sediment exists behind the dam, above the relic channel and within the historic floodplains along river left. The limit of impounded sediment, based on our interpretation of the bed sediment, topographic data and sediment wedge, is at approximate Station 13+25, and is indicated by a note on Sheet 3.

### Volume Potentially Released During an Uncontrolled Failure

With respect to the amount of material that may be mobilized during an uncontrolled failure, based on this conceptual level of this study, and lack of a project sediment transport model, this can be difficult to estimate. However, if we make the assumption that the sediment transported will be limited to the impounded area and the stream will want to 'find' a stable slope during a hypothetical large storm event, we can assume that the channel will headcut back to approximate station 14+00, or the limits of our proposed pilot channel.

Assumptions regarding the amount of dam failure are required as well. Considering the dam removal alternatives presented under Task 4-2 below, we can assume that the extent of dam failure is equal to the median value of proposed dam removal, or 94 linear feet of dam failure.

While the extent of potential headcut matches the upstream limit of our pilot channel construction, and since the extent of dam failure matches Alternative A3, which is the alternative evaluated for this memo, for the purposes of this exercise we'll make the conservative assumption that the amount of material that may be mobilized during an uncontrolled failure is equal to the amount of material we proposed to remove as part of Alternative A3, or 11,100 CY. The details of proposed sediment removal for this alternative are discussed further under Task 4-1.

Note that the assumptions made to support this calculation are arbitrary and were only made to develop a rough conceptual idea and estimate of potential material that could move beyond the dam given a dam failure. In the event of a failure, many different variables would be at play and a number of different factors could lead to a wide range of release scenarios.

## Volume Released During and After Dam Removal

Similar to other dam removal projects in Vermont, this project will be required to file for a state Stream Alteration Permit, a US Army Corps of Engineers Vermont Category 2 General Permit, and other similar permits, where the prevention of sediment transport to downstream reaches is of primary concern. These permits will require the contractor to have erosion protection and sediment controls in place prior to any work; will require that a plan be in place for bypassing flows around the work area; and may require staged land disturbance to ensure limitations on concurrent disturbances of soils. However even with these controls in place, there will be a small amount of sediment that may bypass these controls and be transported downstream. Based on our experience with dam removals, the transported amount can usually be considered negligible, or, as a temporary negative impact (i.e. lasting hours to days) that is out-weighted by the long term gain (lasting years to decades) realized by the completion of a large dam removal and/or restoration project, where the work included restoration of geomorphic functions, floodplain connectivity, aquatic organism passage, etc.

Reviewing the text and calculations presented thus far in this section, the theoretical quantity of sediment that could be released after dam removal would be the total impounded sediment volume of 14,300 CY minus the quantity of sediment proposed for removal as part of the conceptual design (11,100 CY for A3), or 3,200 CY. However, with regards to the pilot channel 'Typical Channel Cross Section' as shown on Sheet 4, final design will incorporate the establishment of vegetation and erosion controls that will help to stabilize any impounded sediments that will remain behind, as part of the proposed final design grading system. The vegetation selected should not only be native, but relatively quick growing, and including rooting systems

that will ensure soil stability over the long term and life of the project. Observed by Stone staff during field work, there are robust stands of willow onsite, within the floodplains and along the stream banks. The revegetation plan should undoubtedly include use of existing onsite willow stakes, in addition to other native species on new surfaces to ensure quick establishment of deep rooting vegetation. Erosion control fabrics made of natural fibers (i.e. coir or coconut fiber matting) can also be used along new surfaces to promote new surface stability while vegetation takes time to root and establish.

Realistically speaking, any sediment released following dam removal will most likely be significantly below the amount calculated in the paragraph above (3,200 CY) with the expectation that the design and vegetation establishment will be successful. More appropriately, the potential quantity to mobilize will be dependent upon any channel adjustments the system might go through as a result of dam removal and pilot channel construction. For example, if following dam removal the Jail Branch attempts to find equilibrium by moving significantly further into a meander bend that was part of the final design, creating an eroded bank resulting in sediment conveyed downstream, the released quantity can be estimated from the amount of soil loss at the meander and quantified by field measurements. Given the tendency of these natural systems to adjust, the design/construction tolerances and limits on construction funding, post-project adjustments are common and almost inevitable. Predicting their quantity in terms of sediment volume, however, is difficult in any design stage.

Overall, if the pilot channel is designed at a slope that matches adjacent channel slopes, within reason (i.e. +/-25% of adjacent slopes), and stabilization of disturbed surfaces (i.e. banks, floodplain surfaces, slopes, etc.) is successful, the majority of sediment conveyed after dam removal should equal the bed load of the fluvial system. Additions to that quantity are possible if there are post-project channel adjustments that result in bed, bank or floodplain surface erosion, as discussed in the preceding paragraph.

### **Bed Sediment Observations**

On September 4th, 2020, Stone mobilized onsite to collect sediment samples. Stone collected 5 sediment grab samples within the limits of the impoundment to characterize the quality of impounded sediment. The samples were collected in a linear fashion throughout the impoundment, and samples were collected from visibly distinct, or different bed material types. The sample locations were located via GPS and are shown via green square symbols and text on Sheet 3. Stone staff waded to each sample location and used a shovel to collect sediment samples from the first 6 inches of depth. Samples were placed in appropriate jars and bags, placed in a cooler with ice, and sent to the University of Vermont Laboratory for grain size distribution (ASTM D6913) and total phosphorous (EPA 3050B). While we anticipated having lab results by the writing of this memo and planned on discussing the results, the laboratory has yet to provide results and therefore they are not included. As soon as they are received, Stone plans to share the results with the project group.

At two of the five sediment sampling locations, samples included a mix of large material (i.e. cobble, gravel down to fine sand) along with smaller material (smaller than fine sand). Stone performed pebble counts at these two locations, and the count data will be appended to the grain size distribution data once received by the lab. In addition to the sampling, Stone recorded observations of bed sediment while wading upstream. Table 6 provides a summary of those observations:

Sampling Station	Dominant Particle Size (inches)	Bed Sediment Observations
HM-S1	Silt to fine sand	The finest/smallest material in the impoundment; dark brown to black color
HM-S2	Silt to coarse sand	Very little to no gravel
HM-S3	Coarse sand, trace silt	Very little to no gravel
HM-S4	Medium gravels	Midchannel bar and beaver dam upstream of this area
HM-S5	Gravel and cobble	Bed looking more like reference reaches; most likely limit of impoundment
HM-S6	Medium gravels	No sample

Table 6. Summary of I	Bed Sediment	Observations
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## Sediment Quality Analysis

During collection, Stone observed the sediment and sampling location for visible and olfactory cues for any contamination. None of the samples exhibited any sheens, films or other visible signs of contamination, and there were no odors, beyond the typical organic/sulfur smell associated with the fine sediments that exist behind the dam. Stone continued the sediment quality analysis by performing a desktop review of past and present land use in the watershed, and also a review of state websites that provided publicly available information regarding known contaminated sites. Specifically, Stone created a GIS project and imported a high resolution land cover data set (developed by the Vermont Spatial Analysis Laboratory; published 2019), in addition to a hazardous sites layer downloaded from VCGI (updated 2016). A review of the current and historical land use, and a lack of any contaminated sites within the watershed provided no reason to pursue additional sediment quality analyses in Phase 2 of this project.

We had intended to utilize the sediment sampling data, specifically the grain size distribution results to further determine whether additional analyses would be required. This intention was based on whether the impounded sediments were predominantly silts and/or clays, understanding that finer particles are more likely to retain chemicals compared to medium to coarse sands. The sediment sampling results are not yet in hand, so this portion of our analysis has not been completed. However, since our land use analysis did not produce any significant sources of contamination within the watershed, at this time we feel there is still no reason to pursue additional analyses.

## Sediment Management Plan

At this conceptual level, our plan for managing sediment associated with dam removal consists of the following items:

- 1) <u>Impounded Sediment</u> Complete 30% pilot channel design (profile, planform and section) and finalize sediment removal quantity
  - a. Obtain grain size distribution results from lab for five sediment samples; complete characterization of surficial impounded sediment, to support disposal/reuse plan
  - b. Phase 2 to include determining either disposal sites and/or beneficial users of excavated sediment; also include plan for trucking relative to safety and neighborhood impacts
- Potential Volume Release During Construction Phase 2 design to include input from Agencies via permitting process, and inclusion of sediment transport controls (i.e. EPSC, flow bypass, etc.) in design and to be implemented during construction
- 3) <u>Potential Volume Release After Construction</u> Complete 30% design for pilot channel section, specifically long term vegetation establishment design for floodplain surfaces and slope stabilization

The details of this management plan will be further fleshed out during completion of 30% designs and during Phase 2 designs, as appropriate.

# 3. Modeling

# Task 3: Hydrologic and Hydraulic Modeling

# Hydrologic Peak Flow Analysis

Stone staff delineated the geographical region contributing flow to the site and determined the watershed size to be 6.65 mi². Streamflow data from nearby USGS gauges were then used to determine peak flow rates using a gauge transfer technique. Stone located 3 gauges within 50 miles of the site and chose 2 of those 3 gauges for further analysis based on watershed size relative to the Jail Branch watershed, geology and surficial soils, length of period of record, and presence of obstructions to flow (ex. dam or withdrawal). At each gauge, a Log-Pearson Type III distribution was used to determine the 2-, 5-, 10-, 25-, 50- and 100-yr recurrence interval design flows. For each gauge, an additional hydrologic analysis was performed that compared records to data collected after 1970, to identify if the hydrology at each site was impacted by a recent shift in hydrologic regimes as a result of climate change. The resulting distributions were plotted and compared to the StreamStats distribution.

The East Orange Branch, near East Orange, Vermont gauge (#01139800) was selected to determine peak flows at the site due to its long period of record due (61 years), its comparable watershed size (8.8 mi²), proximity to the site, location along an unregulated stream and the fact that it is still an active gauge. Because

the post-1970 flows were higher than those corresponding to the entire record at this particular gauge, the post-1970 flows were used for our analyses.

The USGS gauge transfer technique was used to relate the calculated peak flows at the East Orange Branch gauge to the site using the following equation:

$$Q_u = \left(\frac{A_u}{A_g}\right)^b Q_g$$

where  $Q_u$  is the estimated flow statistic for the ungauged site,  $A_u$  is the drainage area for the ungauged site,  $A_g$  is the drainage area for the stream gauging station,  $Q_g$  is the flow statistic for the stream gauging station, and b, depending on the state, may be the exponent of drainage area from the appropriate regression equation, a value determined by the author of the state report, or 1 where not defined in the state report (for this project a value of 1 was used).

The resulting peak storm flows for Jail Branch are provided in Table 7.

Table 7: Summary of Peak Flows at Jail Branch

Recurrence	Flow
Interval	(11/5)
2	215
5	336
10	433
25	576
50	701
100	839

Abbreviations: ft = feet; s = second Date and Author: 09-14-2020 / MRA Pathname: O:\PROJ-20\WRM\20-007 Hands Mill Dam\Data\Hydrology\HandsMill_FPF_and_Summary.xlsx Fish Passage Flows Analysis

High and low fish passage flows were estimated to assess potential fish passage conditions at the site following dam removal. Daily streamflow data was downloaded from the East Orange Branch gauge and used to calculate the 5% and 95% exceedance flows (seasonal high and low flow) during September to November, when brook trout migration is likely. The 5% and 95% exceedance flows were also calculated using daily streamflow data from the entire year. The fish passage flows calculated for both time intervals are provided in Table 8.

### Table 8: Fish Passage Flows at Jail Branch

	Sept – Nov	All Months
	Fish Passage Flow	Fish Passage Flow
Flow	(ft³/s)	(ft³/s)
High	15.6	31.7
Base	4.0	6.7
Low	1.2	1.3

Abbreviations: ft = feet; s = second Date and Author: 09-14-2020 / MRA

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The flow scenarios above were simulated using a hydraulic model described below.

### Hydraulic Model Development

Stone used the US Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System model (HEC-RAS; http://www.hec.usace.army.mil/software/hec-ras/) to develop a one-dimensional, steady flow hydraulic model of Jail Branch, the dam and its floodplains. This model was used to simulate the peak flows and fish passage flows calculated above for existing and proposed conditions.

The basemap developed as part of Stone's assessment of the existing conditions at the site was the source of the topography and bathymetry for the existing conditions hydraulic model. Stone staff exported the TIN surface as a digital elevation model (DEM) and then imported the DEM into HEC-RAS Mapper to create a terrain model, which supported the development of the geometry file in HEC-RAS.

Once the geometry file was created, the dam structure and features such as natural levees, ineffective flow areas, stream bank stations, distances between cross-sections, Manning's roughness coefficient at each cross-section were more fully defined. Survey data collected by Stone staff were used to specify the dam locations and dimensions in the existing conditions model. Manning's n values were selected based on channel surface roughness, vegetation, and channel features such as pools.

HES-RAS requires boundary conditions to set the starting water surface elevation at the upstream and/or downstream ends of the river system being modeled. Additionally, a flow regime (subcritical, supercritical, or mixed) must be selected for each analysis. For this conceptual design, each steady flow analysis was completed using a subcritical flow regime, which is well suited for preliminary dam removal evaluations. For the final 30% design deliverables, if warranted we will consider using a mixed flow regime, which is suitable for situations where flow may pass through subcritical to supercritical or supercritical to subcritical regimes. Since the subcritical flow regime was used, only a downstream boundary condition was specified. The downstream boundary condition was set to normal depth with an energy slope of 0.0055, for all flow profiles. The energy slope was estimated based on the channel slope in the vicinity of the downstream cross sections.

The boundary condition was set at cross-sections sufficiently far away from the area of interest as to minimize errors due to estimating the starting water surface elevation.

The peak flow and fish passage flow values calculated using gauge transfer and statistical techniques were entered into the HEC-RAS flow file that was used for both the existing conditions and proposed conditions models. For the purposes of this memo, the model began after the junction of Jail Branch and the Unnamed Tributary and a constant discharge was used throughout the system. For the final 30% design deliverable, the model will be modified to include the tributary junctions and incoming flows will be apportioned to each tributary based on tributary watershed size. Table 7 lists the peak flow conditions simulated and Table 8 lists the fish passage flow simulated.

# Existing Conditions Hydraulic Analysis

The hydraulic analysis completed for the existing conditions provides insight into the expected water surface elevations, water velocities, flood inundation limits, and barriers to fish passage for the flow scenarios analyzed. A longitudinal profile for existing conditions, including water surface elevations for specific flow scenarios, is provided as Figure 2.

# Proposed Conditions Hydraulic Analysis

For this memo, Stone developed a one-dimensional hydraulic model to simulate flow conditions for Alternative A3. The other alternatives (as listed under Task 4-2) will be run as part of the 30% design effort and results will be provided in the final 30% design report. The model for Alternative A3 was developed based on approximately 94 linear feet of dam removal, the extents of which are shown on Sheet 3. The model also incorporates the removal of approximately 11,100 CY of impounded sediment behind the dam; which is simulated in the model via a revised pilot channel slope as shown on Sheet 4 (see dashed blue line in the profile at top of sheet) and the dimensions of the Typical Channel Cross Section also provided on Sheet 4, which includes bank stabilization measures and incorporation of a 30' wide floodplain bench along river left (green shaded area on Sheet 3).

With respect to dam removal, the following three scenarios have been developed as part of the alternative's analysis (Task 4-2). As discussed above, only A3 was modeled for the purposes of this memo:

- 1. Alternative A1: No Action.
- 2. Alternative A2: Removal of 44 linear feet, including the embankment section and principal concrete spillway.
- 3. Alternative A3: Removal of 94 linear feet, including the embankment section, principal concrete spillway and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place.
- 4. Alternative A4: Removal of the entire dam (165 plus any dam portions that are buried).

Table 9 below provides a comparison of the 100-year recurrence interval flood water surface elevations at the dam for the existing condition and Alternative A3. Figure 2 provides a plot of water surface elevations for the existing condition and proposed condition, for Alternative A3. Note that the stream thalweg for the existing condition is black, and the thalweg for A3 is pink.

Table 9: Water Surface Elevation Comparison for the 100-Year Recurrence Interval Flow

Scenario	100-yr WSE (ft)	Linear Feet of Dam Removed
Existing	1281.16	0
Alternative A1	1281.16	0
Alternative A2	TBD	44
Alternative A3	1266.13	94
Alternative A4	TBD	165

Abbreviations: ft = feet; WSE = water surface elevation Date and Author: 09-15-2020 / GMB

> HandsMillDamRemoval Plan: 1) HM_Existing 9/22/2020 2) HM_Proposed 9/21/2020 Jail Branch Jail Branch



Figure 2. Profile of HEC-RAS output showing water surface elevations for existing and proposed conditions. Water surface elevations (blue lines) that follow pilot channel thalweg (pink line) are storm peak flow water surfaces following dam removal.

While Alternatives A2 and A4 still need to be run, it is evident that most removal scenarios should provide significant improvement and reduction in water surface elevations compared to those of the existing condition. While Scenario A3 provides an improvement in water surface elevation (i.e. >15' WSE reduction) for the median amount of dam removal, we expect that Alternatives A2 and A4 will produce water surface elevation reductions in proportion to the amount of dam removed. As we move through the 30% design, in addition to cost optimization considerations that will be part of the Benefit Cost Analysis (BCA), we'll also consider public safety, as well as both long term channel and structure stability when considering the most appropriate alternative.

# 4. Field Investigations and Modeling Summary Memo

## Task 4-1: General Concept Design

Stone developed a concept designed based on characteristics of the reference reach, keeping in mind infrastructure constraints throughout the project area, maintenance of floodplain connection, construction access and reasonable construction costs.

Based on inspection of the longitudinal profile developed from the topographic survey, the average slope of the reference reach was 1.5%. A similar average slope of 1.7% was observed in the unnamed tributary. Using the more conservative slope observed in the reference reach, a slope of 1.5% was used as a basis of design for the pilot channel.

Typical of other dam removal and channel restoration projects, a downstream starting point, or tie in point where the pilot channel would begin was required. As shown on Sheet 4, there is a large sediment wedge just downstream of the dam. This material consists of medium to large sized boulders that is most likely comprised of dam material that has broken off over the past few decades, material that has been transported downstream and over the dam during large storm events, and native surficial material that has been exposed due to high erosive forces. We expect that this material is immobile in this location except during extreme storm events. Because most of this material is sourced from the dam itself and its presence in this location is not geomorphically appropriate, we proposed to remove the sediment wedge material and tie in the pilot channel just downstream of the wedge, at the first downstream grade control at approximate station 5+08. It is estimated that the sediment wedge is made up of approximately 550 CY and it's anticipated that this material will be incorporated into other parts of the design (as stone steps, bank stabilization, etc.).

Continuing upstream with a series of riffles and 1' stone steps at an average pilot channel slope of 1.5%, the pilot channel meets the existing channel bed at approximate station 14+00. This conceptual design results in a total of 7 stone steps and riffle sequences ranging from 70-140 feet long.

The pilot channel in cross section would follow the 'Typical Channel Cross Section' as shown on Sheet 4. The pilot channel cross section design includes bankfull dimensions as discussed earlier, a 30' wide floodplain bench along river left and will slope up from that bench back to existing grades, at an approximate 2:1 (H:V) slope. The floodplain bench would be planted with native vegetation and the 2:1 slope would also be planted with similar vegetation and stabilization measures (i.e. live stakes, fascines, etc.). For this concept design, the floodplain bench was maintained along river left due to the proximity of residential housing, the Town yard and natural grade features that exist along river right. As discussed under Task 2-7, construction of this cross section over the extents of channel restoration results in an estimated impounded sediment removal volume of 11,100 CY.

The concept plan also includes approximately 94 linear feet of dam removal, including the embankment section, principal concrete spillway and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place. The total amount of dam material to be removed is estimated at 286 CY. Total material cuts at the dam are estimated to range from 12-14 feet.

Sheet 3 also shows an approximate proposed pilot channel right top of bank in the vicinity of the dam. While this boundary is conceptual, it connects the upstream right bank with the same bank downstream, while taking into account the proximity of the Town yard and existing grades. Overall, the geometry of this concept pilot channel in the vicinity of the dam, particularly the planform is not geomorphically consistent with the planform of Jail Branch outside of the project area. As we move through 30% design, Stone will consider adjustments to planform in the dam area and will consider channel realignment, in order to achieve a planform that is more natural and consistent with reaches in and out of the project area.

# 1.1.1. Task 4-2: Alternatives Analysis

Based on field work, modeling and concept design development performed thus far, Stone has developed the following project alternatives:

- <u>A1 No Action</u> The dam and impounded sediment remain in place. Given the trajectory of historical inspections and current state of the dam, the potential for dam failure would be expected to increase over time.
- <u>A2 Removal of 44 linear feet</u> Includes the embankment section and principal concrete spillway only. While this alternative would not allow the continuance of a floodplain bench through the dam area, this alternative is included for comparison purposes.
- <u>A3 Removal of 94 linear feet</u> Including the embankment section and principal concrete spillway, and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place.

<u>A4 - Removal of entire dam</u> - 165 linear feet plus any dam portions that are buried. This alternative may be required if cuts in the dam area are deep enough (i.e. ~12 feet) such that the concrete training wall is undermined, and would not be stable over the long term.

While Alternative A3 was run through the hydraulic model for the purposes of this memo, A2 and A4 will also be run through the model as part of the 30% design effort. And while all alternatives were not modeled for this memo, we were able to develop costs for each alternative, based on quantities calculated. Table 10 below provides a summary of the typical engineering opinion of probable costs (OPCs) for each alternative, in addition to life cycle costs calculated per Attachment B of the RFP.

Alternative	Typical Engineering OPC (\$)	Life Cycle Costs (\$)
A1	\$0	\$0
A2	\$340,100	\$181,843
A3	\$372,000	\$193,442
A4	\$405,400	\$205,560

Table 10: Summary of Costs for Alternatives

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The OPCs have been developed to the 15% design level. They include volumes for concrete and sediment removal, and other quantities estimated from the drawings and knowledge of the site. We've used unit costs based on 2-year average unit cost data maintained by VTrans (http://vtrans.vermont.gov/cost-estimating), and unit costs from recent construction projects for similar bid items. Per standard cost estimating methodologies developed by the US Army Corps of Engineers, the OPC includes a 20% contingency to account for unforeseen construction costs related to site conditions, variability in pricing, etc. Also per Corps standards, as the project advances through subsequent design refinements and estimates of costs become more certain, the contingency will be reduced down to 10% for the 100% design submittal. The costs also include mobilization/demobilization costs, estimated at 10% of the construction costs. These costs do not include final design engineering fees, permitting or bid phase services (however those costs will be provided in the final 30% design report).

Life cycle costs were based on Attachment B to the RFP, and the United States Department of Agriculture Rural Utilities Service Bulletin 1780-2, Preliminary Engineering Reports for the Water and Waste Disposal Program, as provided on the state's State Revolving Fund website (https://dec.vermont.gov/waterinvestment/water-financing/srf/srfstep1/PER). Life cycle cost analysis (LCCA) consists of adding all initial and ongoing costs of the project over the life of the project, subtracting the salvage value of the project at the end of that time, and adjusting for inflation. With regards to annual costs, Stone assumed an annual cost of \$2,000 to account for vegetation establishment and/or management, over an assumed 20 year project life. We also assumed \$5,000 of 'repairs' every five years of the course of the project, accounting for any repairs or stabilization that may be required due to channel adjustments or any other unforeseen issues.

Although not included here, as part of the proposal we suggested that a phased removal be considered as a dam removal alternative. In this approach, a contractor would mobilize to the site 2-4 times total, typically once per year, and remove a portion of the dam, allowing a portion of the impounded sediment to move downstream over the course of that year. This approach might be more appropriate for impounded sediments that are more coarse, as compared to very fine sediments that may negatively impact downstream biota, with the repeated releases. As part of the final 30% design effort, Stone could evaluate this option to see if it would result in reduced construction costs, compared to a typical removal project that involves the excavation and hauling of the impounded sediment. It should also be noted that this approach has been considered for other Vermont dam removals and regulators are familiar with the approach. This alternative can be pursued pending discussions with the Winooski NRCD and stakeholders, and results of the sediment analysis.

# 5. References

Town of Washington Planning Commission, 2013. Washington Town Plan. Adopted by the Board of Selectmen, November 12, 2013.

Town of Washington and Central Valley Regional Planning Commission, 2013. Local Hazard Mitigation Plan. Created August, 2013 – Adopted April, 2014.



# Legend

— 1280 —	– Major Contour
<u> </u>	— Minor Contour
	– Edge of Road

**EXAMPLE 1** Proposed Limits of Disturbance



HANDS MILL DAM REMOVAL AT JAIL BRANCH SURVEY EXTENTS PLAN AND LIMITS OF DISTURBANCE

WASHINGTON



# Legend

$\bigtriangleup$	Survey Control Point
	Major Contour
	Minor Contour
	Parcel Boundaries
	Edge of Road
•••••••••••••••••••••••••••••••••••••••	Guard Rail
— OHU— — —	Overhead Utility
9	Tree
	River Top of Bank
×98.17	Thalweg Spot Elevations
С	Utility Pole
Θ	Manhole
0	Sanitary Manhole or Septic Cover
0	Well
۲	Vent
æ	Hydrant
凶	Water Valve
36" CMP	Stormwater Pipe
<b>—</b> · <u> </u>	Stormwater Swale
● <i>P</i> -6	Sediment Probing Location
■ HM-S1	Sediment Sampling Location

**EXAMPLE 1** Proposed Limits of Disturbance

# Survey Notes:

- The vertical datum refers to NAVD88. Horizontal datum refers to Vermont State Plane Grid NAD83. Contour interval = 1 foot.
- 2. Contours were created using two sources of data: 1) a topographic survey of the channel bed, banks, floodplains and structural features collected by Stone Environmental, and 2) LiDAR data of upland features, obtained from the Vermont Center for Geographic Information.
- 3. Site survey was performed on August 11 and 12, 2020 by Gabe Bolin, PE, of Stone Environmental, Inc. using a Stonex S900 GPS base and rover.
- 4. Survey data provided in these plans do not represent a boundary survey.
- 5. Utility locations shown on this plan should be considered approximate. Contractor is required to verify utility locations prior to work.



HANDS MILL DAM REMOVAL AT JAIL BRANCH EXISTING CONDITIONS

WASHINGTON



